FOREWORD

INTRODUCTION

The Arizona Department of Transportation (ADOT) has used the American Association of State Highway and Transportation Officials (AASHTO) Design Guide for Pavements since 1962 when the first design guidelines were published as a result of the 1958-1960 Road Test. In 1986 AASHTO published a comprehensive revised version of the Pavement Design Guide (1). As in previous versions, AASHTO asked each state to review and modify the guide based upon their unique climate, materials, pavement performance, construction and maintenance practices. Arizona's present pavement design guide was developed by Materials Section in 1981 and revised in 1984 (2). Each service area; Materials Testing, Pavement, and Geotechnical, contributed to the development of this manual. In particular, the following individuals made significant contributions.

* George Way
* Jim Demaree
* Jim Delton
* John Eisenberg
* John Lawson
* Brad Mortensen
* Gregg Inman

The manual generally incorporates the principles of the new AASHTO Design Guide with appropriate Arizona modifications. The use of this new pavement guide presently impacts about 125 project pavement designs per year, with a value approximating 200 million dollars.

DISCUSSION

The pavement designer's job is to design a pavement structure sound enough to resist premature failures, such as poor ride, excessive cracking, potholes due to poor structural support, permanent deformation (rutting), low skid resistance, stripping (asphalt debonding) and raveling, in a cost effective manner and perform as expected during its predicted life. To do this a myriad of factors assumptions and predictions need to be addressed.

Traffic loading has consistently been a troublesome factor to predict. Equivalent Single Axle Loads (ESAL's) have historically been calculated by the AASHTO procedure with a few simplifying assumptions; which include setting the structural number equal to five (5), the concrete thickness to nine (9) inches and the terminal serviceability to 2.5 psi. These simplifying assumptions are in keeping with the method used by the Federal Highway Administration to calculate ESAL's as a part of their annual Truck Weight Study (also referred to as the loadometer study). To further improve the traffic loading predictions Arizona has not only incorporated the growth of future traffic, but also truck loading increases and tire pressure into the new 1988 traffic loading calculation. These new calculations reflect heavier trucks and heavier steering axle loads, which can be 5 to 10 times more damaging then dual tire, tandem axle loading. In addition, tire pressures are now estimated at 105 PSI instead of the AASHTO Road Test 75 PSI. These changes are in keeping with research conducted by the University of Arizona (3) and Austin Research Engineers (4). These traffic loading changes are an interim step to the ultimate use of weigh-in-motion data. It is Materials Sections goal in cooperation with Transportation Planning to incorporate weigh-in-motion data in the 1989 traffic loading estimates. The net effect of all of these changes is that the predicted traffic loading estimates have doubled since 1987 and will probably increase again when WIM Data is implemented. Although this represents an improvement over past practice, estimating future traffic is still a major area of concern in areas of the state experiencing tremendous growth. With this in mind, many design values have been selected to provide insurance against under estimating traffic. Higher service levels were selected to reflect the need to reduce maintenance and traffic interruption on high traffic volume highways.

Environment and climate also impact pavement performance by changing the moisture content of highway materials and imposing damage by freezing and thawing. The new manual describes these changes in terms of a seasonal variation factor, which is equivalent to the Arizona regional factor. This approach was selected because previous Pavement Management research (5) indicated that regional factor strongly influenced pavement performance. In addition a method for determining the depth of frost damage has also been added.

The interaction of moisture and climate alters the roadbed soil strength. This relationship was expressed by equating results of the R-value test to soil strength in terms of Resilient Modulus (M_R). After much discussion and review of the 1986 AASHTO Pavement Design Guide, as well as, the review of previous Arizona Research (6)(7), it was determined the R-value soil strength relationship should be changed to better match the actual long term soil strength (moisture) conditions in the field. In particular, soil strength is a function of the seasonal variation factor, thus the same soil in Flagstaff will have a lower soil strength than in Phoenix due to the higher rainfall and severe freezing and thawing climatic conditions. Another change in characterizing soil strength involves using the average soil strength of the predominant soil type instead of the current practice of representing the poorest soil. Also, geosynthetics will now be given credit for improving the subgrade quality. In general, the philosophy of the new manual is to either remove, stabilize or control the subgrade materials in such a manner that the average subgrade soil strength occurs as uniformly as practical.

The interaction of moisture, soil strength and traffic loading can be very damaging. The 1986 AASHTO Guide places special emphasis on drainage. Likewise, Arizona has given value to geosynthetics, drainage layers, trenches and pipes to remove moisture rapidly and mitigate damage. Methods to remove excess moisture under the pavement will become more common in the higher rainfall areas of the state.

Predicting pavement damage and pavement performance is a difficult forecasting problem. To help improve the quality of the forecasted performance, Arizona has relied upon its pavement management data base which represents 15 years of historical pavement performance data. In addition, present serviceability index factors are set to conform with the Department's published Pavement Preservation Policy (8). To achieve the policy standards, high traffic volume roads need to be rehabilitated at a much higher terminal serviceability index, which for consistency are reflected in the design values. To use any lower terminal servicability values would unduly increase the cost of future maintenance and rehabilitation.

The reliability or confidence that a pavement will perform as designed has indirectly been a part of the AASHTO Pavement Design process. Because of the previously discussed numerous changes in the 1986 AASHTO pavement design, as well as Arizona changes in pavement design, reliability factors had to be tested at various levels to be sure that the selected factors would yield designs of at least the same structural number or thickness for the same soil and traffic.

To help illustrate these changes a limited sensitivity analysis involving three levels of traffic was conducted (9). AASHTO traffic refers to typical calculated traffic loads in 1987. Truck and tire pressure traffic loading reflect new changes in calculation due to predicting heavier trucks and higher tire pressure. A weigh-in-motion (WIM) traffic loading was estimated from previous sample information and reflects the anticipated higher loading. In general, greater traffic loading equates to a 5 to 20 percent increase in AC/PCCP thickness. To be more specific the increase in AC thickness will be about 20 percent, primarily because there is a greater increase in the AC pavement safety factor. Under the new manual AC thickness can be reduced by improving the subgrade strength and/or improving drainage. Concrete thickness increases only about 5 percent primarily because it already had a safety factor of two. With very heavy traffic the design concrete thickness can become very large. The new manual provides a means for reducing thickness by using load transfer dowels or continuously reinforced concrete. In addition, tied concrete shoulders will also reduce the concrete slab thickness.

Given the myriad of possible designs, Life Cycle Cost Analysis will be routinely performed on most major construction projects.

The rehabilitation portion of the manual reflects the findings of previous Arizona Research (10). Additions have been made to accommodate milling and recycling.

The remainder of the manual deals with practices and procedures that need to be followed in order to develop an acceptable geotechnical investigation and pavement design.

FOREWORD REFERENCES

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